BOTANICAL GAZETTE.

VOL. X. DECEMBER, 1885. No. 12.

Some Botanical Laboratories of the United States.

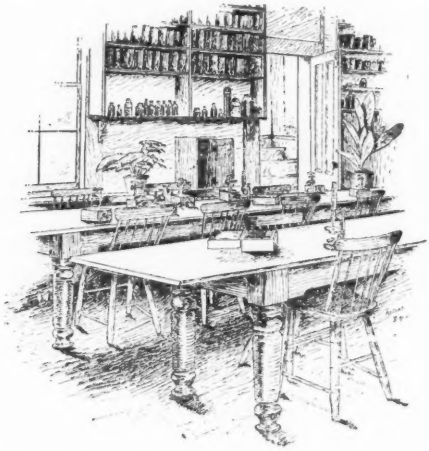
BY J. C. ARTHUR.

It can not be disputed that one of the most powerful auxiliaries to the advancement of botany in this country is the laboratory. It leads the way to a wider range of study and a more intimate and thorough acquaintance with the structure and life of the plant. Its tendencies are toward habits of careful investigation, and through this channel we are to look for the more recondite studies in vegetable anatomy and physiology which will compare favorably with those of zoology. The fact that the laboratories of the German universities annually attract many students of botany from this country shows the interest in this method of study, and at the same time a reactionary influence is evident in stimulating and shaping our own institutions of like nature.

But have we yet any American laboratories worthy of the name that will at all compare with those of Germany? If we ask the masses they would probably say no, they had never heard of any. But let us instead propound the question to the scientific public. I think we may safely take the *American Monthly Microscopical Journal* as a fair representative of this class. Its editor, a year ago, in championing a doubtful hypothesis, asserted in disparagement of his opponents that "comparatively few of the botanists ever use a compound microscope, and of those who do not many are aware of the amount of labor involved in a thorough microscopical investigation my means of thin sections." When this journal made reply by referring the editor to "the every-day experience of our laboratories," he answered that "the amount of scientific investigation in botanical histology that is being conducted in this country is not very great, and we have not a wonderful array of well-equipped botanical laboratories either. It is not our custom to make assertions in these columns that are not sustained by facts of which we are cognizant." But

if the general scientist is so positive and thinks he could marshal facts in his support, let us turn to the several hundred botanists of the country. Even here the majority would likely shake their heads doubtfully as to the value of our laboratories, an anomaly we shall allude to again.

It is the purpose of this article to give a brief account of a few American laboratories in order to demonstrate both their existence and their capacity. The reader can then judge for himself whether we have laboratories that are noteworthy or not. Among the first to be established was that at the Botanic Gardens



LABORATORY AT BOTANIC GARDENS, HARVARD UNIVERSITY, showing door leading to the herbarium.

of Harvard University, which was opened in 1872. This consists of one principal room with east and west light, and two smaller rooms. The lecture room is adjoining, beyond which are the extensive greenhouses. On the other side of the laboratory one passes up a few steps and through a short passage way into the great herbarium, the largest and most valuable one on the continent, beyond which is the fine Gray library. Students can have access to these under certain restrictions. East of the laboratory lies the Botanic Garden, which furnishes abundant material for study, including aquatic and marsh plants. West of the laboratory is the garden of the North American flora, the corner

for sub-alpine plants, plats of grasses, cactus beds, etc. All these are made tributary to the needs of laboratory students.

The laboratory of cryptogamic botany has, after several transfers, been assigned to a large and well equipped room in the Agassiz Museum. Here is an abundance of light, water, instruments and material, and in an adjoining room the special works of reference and exsiccatæ, probably the most complete in the country, and also the library belonging to the Agassiz Museum, to

BOTANICAL LABORATORY FOR ADVANCED WORK AT CORNELL UNIVERSITY.

which the student can have access. This laboratory is shared by one of the instructors in zoology.

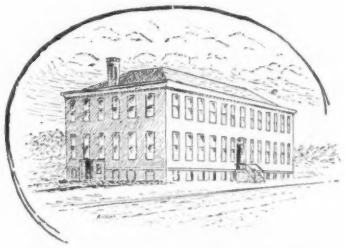
Two years ago provision was made for the main phanerogamic laboratory at College Yard in order to relieve the students of the long walk to the Botanic Gardens. Three rooms of good size in Harvard Hall were plainly furnished but abundantly supplied with instruments and material. There is here an herbarium of New England plants ample for most elementary requirements, and a small library of morphological and physiological works, while

only a short walk across the campus takes one to the main library of Harvard College.

The microscopes used in the Harvard laboratories are Zeiss (1 large stand, 3 No. VI), Verick (12), Leitz (3), Wales (1), Ross (1), and a set of six objectives by Tolles, with plenty of accessory apparatus.

Excellent provision is made for physiological work, for which there is ample supply of ordinary chemical and physical apparatus with such special appliances as micro-spectroscopes, auxanometers, clinostats, thermo-regulators, etc.

The laboratories are in general open three days in the week from nine until five, except for special students who can attend every day except Saturday and Sunday. There can be accommodated at one time in morphological work sixty, in biological course



BIOLOGICAL BUILDING OF UNIVERSITY OF PENNSYLVANIA.

thirty, in histology fourteen, in advanced cryptogamic botany six and in advanced vegetable physiology and systematic botany twelve.

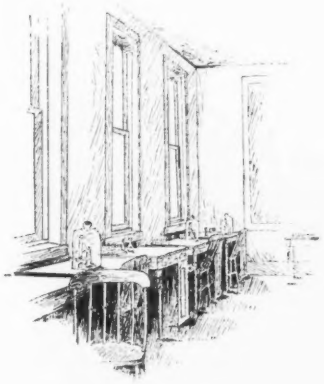
Every facility and encouragement is provided for original research, and the number of teachers of botany who come for study each year gives evidence of the wide appreciation of the opportunities. Taken as a whole the botanical laboratories of Harvard University are the most extensive and important in the country.

The botanical building at Cornell University consists of a main part erected in 1872, 97 by 58 feet, three stories high, which contains what is probably the finest botanical lecture room in America, and an excellent economic and illustrative museum of botany. A two-story extension, 35 by 30 feet was put up in 1882, which with some of the older part is entirely devoted to laboratories. This structure although forming a part of the large build-

ing known as Sage College was built expressly for the botanical department.

The laboratory for analytical and general phanerogamic work is on the second floor, 32 by 22 feet, lighted from three sides and provided with movable tables at which two can sit. Eleven dissecting microscopes are found ample, as students furnish their own lenses for ordinary work. Forty or fifty students can be accommodated here at one time.

The laboratory below, 62 feet long, contains twelve tables supported from the wall, having north light, and with room for mov-



SENIOR LABORATORY IN THE BIOLOGICAL BUILDING OF UNIVERSITY OF PENNSYLVANIA.

able tables when required. Most of the microscopic and physiological work is done here. There are twelve microscopes, made by Tolles (2), Verick (2), Gundlach (1), and the later purchases by Bausch & Lomb. They are mostly fitted with $\frac{3}{4}$ and $\frac{1}{6}$ inch objectives, with additional higher objectives and suitable accessory apparatus.

This room opens directly into the extensive and elegant conservatories which supply abundant material for dissection. The herbarium is ample for the need of students, and is especially full in grasses and sedges. A special aid and incentive to botanical work is the wonderfully rich and varied flora of the immediate vicinity.

The laboratories are open daily except Sunday from eight to five o'clock. Fair facilities are offered for original investigation, especially in microscopic and systematic botany. A bequest which was expected to found an extensive library is now in litigation.

The laboratories of the University of Pennsylvania are in the biological building, erected in 1884. This structure is 84 by 47 feet, two stories high, and a basement. The same rooms are used

BOTANICAL BUILDING OF THE MICHIGAN AGRICULTURAL COLLEGE.

both for zoology and botany. The student first takes a course in general biology with laboratory work in Huxley and Martin's Biology, then Gray's Botanical Text-book accompanied with analytical work, before physiological and anatomical botany is reached.

There are two laboratories, junior and senior, each 30 by 22½ feet, and three of less size, designed for students engaged in special or original work, *all* lighted from the north. Each table is

supplied with a dissecting and a compound microscope, full outfit of chemical appliances, etc., for which the student is held responsible during his connection with the laboratory. Gas is also carried to each table.

Elementary work is done in the laboratory with simple microscopes made by Zentmayer at the request of Professor Rothrock.[1] There are twenty-four compound microscopes, all by Zentmayer. Rooms are open from 9 to 5 o'clock each week day, but on Saturday no one is in attendance.

In the basement are photographic rooms and aquaria. Works of reference are supplied in the building, and the extensive library and herbarium of the Philadelphia Academy of Natural Sciences are also open to the student. For the prosecution of original research, which is specially encouraged, all needed appliances are provided, or if not already in hand are obtained as required.

The laboratory of Illinois University is a room 22 by 28 feet, containing twenty-four tables for one student each, the usual supply of water, gas and shelving, and is exclusively used for botany. There is also the professor's laboratory, in which is the herbarium.

For elementary work with simple magnifiers the student provides his own outfit. The compound microscopes, twenty-one in all, were made by Spencer & Eaton (1), Ross (2), Möller (1), Bullock (1), Nachet (1), Beck (4), Bausch & Lomb (4) and seven were made in the university shops. There are also thermostats, moist chambers, scales, etc. In the same building are good physical and chemical laboratories, from which any needed apparatus may be borrowed.

A greenhouse near the laboratory is tributary to it. The laboratory is open from 8 to 12 and from 1 to 5 o'clock. The present quarters have been occupied since 1876. A special biological building is expected at some future day.

The botanical department of Michigan Agricultural College rejoices in the most imposing building especially erected for botanical instruction in the country. It is a modified Gothic, completed in 1880 at a cost of $6,000. The upper stories contain the botanical museum, very instructively arranged. The laboratory on the first floor, also used as a lecture room, is 48 by 44 feet. It is lighted from east and west, and with ground glass windows on the south. Long tables are placed obliquely at each window, at which a number of workers may sit at a time.

[1] This instrument is described at p. 37, Vol. III, of this journal.

The elementary course, with simple microscopes, permits most of the work to be done outside the laboratory. Coddington lenses with convenient supports are chiefly used. The supply of compound microscopes is at present ample (27), and with funds for the purchase of others as needed. The makers are Zentmayer (1), Sidle (1), Berlis (6), Klein (1), Wales (5), Bullock (1), Bausch & Lomb (11), and one by Ross not now used.

The herbarium and library in the same building are fair size, and meet the needs of undergraduate study. A conservatory and a fine botanic garden, including aquatic plants, a few steps away, and a virgin flora in the vicinity, furnish plenty of excellent material. This laboratory has long been noted for the observant and independent work of its students.

At the University of Michigan a microscopical laboratory was established in 1874 for animal and vegetable histology; since 1879 it has been used exclusively for the latter purpose. Here a large amount of the elementary work is done, much of it being what is known as "microscopy." There are forty-three microscopes, mostly Bausch & Lomb.

The botanical laboratory proper, opened in 1882, occupies a room 40 by 20 feet in the third story of the main building. It is well lighted by eight windows and furnished with movable tables, wall cases, charts, etc. Six Gundlach microscopes with suitable accessories, a small but well selected library containing the works of De Bary, Sachs, Pfeffer, etc., sets of the *Annales des Sciences Naturelles* and *Botanische Zeitung*, are at the service of students. Another room is devoted to the herbarium. The laboratory is open each week day from 8 to half-past 12 o'clock.

A few students each year pursue special investigations, the excellent quality of which is already well known to our readers. The friends of the institution earnestly hope the regents may soon find it feasible to enlarge and more fully equip the department, which has shown itself very worthy of support.

At the Iowa Agricultural College the botanical department has permanent quarters in the second story of North Hall. The laboratory, which was opened about nine years ago and more recently provided for as at present, is 40 by 16 feet and lighted by four north windows. Extending out from each window is a truncated wedge-shaped table, at which two can sit on either side and one at the narrower end furthest from the window. By this arrangement five can comfortably see at each window.

The work with simple magnifiers is mostly done outside the laboratory. There are twenty compound microscopes, partly made

by Schrauer, having Hartnack objectives, but the larger part by Beck, in addition to which is one large binocular by Beck with full complement of objectives and accessories. The laboratory is open four afternoons each week from two to five o'clock.

The herbarium and library occupy an adjacent room. Phanerogams and cryptogams are uniformly arranged and very fully represented, including a large part of the published exsiccatæ. The library is well stocked with standard reference works, both in English and foreign languages.

The new biological building of Wabash College, opened last year, contains two laboratory rooms exclusively for botany. The room for elementary work is 50 by 25 feet, with north, south and east light, fixed and movable tables, an alcove with north light being devoted to work with the compound microscope. For work with simple magnifiers Bausch & Lomb and Beck dissecting instruments are used.

The room for advanced students is 25 feet square, and chiefly lighted from the north. Twenty microscopes are now in use, the manufacturers being Zentmayer (2), Beck (8), McCallister (1), and Bausch & Lomb (9). Some simple physiological apparatus has been provided, and additions to it will be made from time to time. There is a large library especially full in systematic works on phanerogams, and one of the largest phanerogamic herbaria in the west, probably only second to the Engelmann collection. The laboratories are open from nine to four o'clock each week day.

The new arrangements at Wabash College and the liberal attitude of its board of directors, who say that "any book or any material procurable with money will be obtained for original work," give most excellent opportunity for conducting special investigations.

Purdue University opened its laboratory in 1881. It is 40 by 25 feet and furnished with a dozen tables for two workers each. There are twenty-five available microscopes, made by Beck (11), and Bausch & Lomb (14), with an additional set of Beck's objectives up to $\frac{1}{2.0}$ in., and A and E of Zeiss. An equal number of dissecting microscopes, made by Beck (4), and Bausch & Lomb (21) meet the requirement for simple magnifiers. The room is open on Saturday from nine to twelve o'clock, on other week days from nine to four. The future is expected to bring new rooms and additional facilities to this promising beginning.

The laboratories of the University of Wisconsin, established in 1881, are located in rooms intended to answer the purpose for some time to come. Some work in zoology is done in them, while

the zoological laboratories, which were burned not long since, are being rebuilt, otherwise they are exclusively for the botanical department. The main laboratory, 36 by 22 feet, now arranged to accommodate twenty students at a time, is to be doubled in size. The laboratory for advanced and micro-chemical work consists of a suite of rooms covering equal space with the main laboratory. The rooms are open from four to five hours each week day.

Eleven Bausch & Lomb dissecting microscopes are provided for elementary work. There are twenty-five compound microscopes, made by Gundlach (1), Bausch & Lomb (3), Schrauer (2) with Wales objectives, and Leitz (19), also three Abbe condensers, as many homogeneous immersion lenses, an Engelmann microspectroscope and culture apparatus for bacteria investigations. A very good botanical library and phanerogamic and cryptogamic herbarium occupy rooms in the same building. Plant diseases and parasitic fungi are especially well illustrated in both library and herbarium.

The botanical laboratory at the University of Nebraska was first opened in April, 1885, and at present occupies a room, 25 by 18 feet, fitted up to accommodate eight or ten students at a time. It will shortly be removed to rooms in the new Chemical Hall, ample for twenty-one students at once, to be occupied until the large and commodious biological building is erected, which is expected in about two years. The rooms are now open seven hours a day, but it is proposed to reduce this somewhat.

Twenty-five dissecting microscopes and thirty-six Coddington lenses have been provided for elementary work, which is not yet under way. The compound microscopes are by Beck (15), and Bausch & Lomb (6), and in addition one large Beck instrument with a dozen objectives and a full set of accessories. There is already a very fair botanical laboratory and many sets of exsiccatæ.

The last laboratory to be mentioned in this article, that of the Shaw School of Botany at St. Louis, is also the most recent one organized. The formal opening of this new institution occured Nov. 6, 1885. A two-story dwelling house, near the Washington University, of which the school is a department, has been remodeled for laboratory purposes. At some future time a fully equipped laboratory building will be erected, probably at the Shaw gardens. These gardens are very extensive and elaborate, and far exceed those of any other botanical school in the country.

The instruments now ready for use are sixteen Bausch & Lomb dissecting microscopes, one of Zeiss' best stands, with objectives ranging up to $\frac{1}{18}$ homogeneous immersion and full accessories in-

cluding spectroscope, and three Leitz stands with powers ranging to $\frac{1}{16}$ and $\frac{1}{20}$ homogeneous immersion.

The present library consists of the Engelmann library and the pamphlet collection of Dr. Trelease, the professor in charge. The herbarium consists of the large Engelmann collection, the Bernhardi herbarium of perhaps 20,000 species, Riehl's Missouri plants, about 10,000 European plants from the Joad collection, secured through the kindness of Dr. Gray, and the excellent collection of cryptogams of Dr. Trelease. This institution will undoubtedly have unexcelled facilities for post-graduate work and research in the near future.

The foregoing sketch of the botanical laboratories of twelve prominent institutions of learning does not by any means include all there are in the country, but we think sufficiently demonstrates the present condition of American laboratories, and is at any rate as extended as our space permits. Others will be described at some future time.

The laboratory system, in connection with the teaching of botany, may be said to have been introduced in this country about 1870. The next five years saw the beginning of a number of laboratories, usually with limited means and room; but by 1880 their magnitude and importance had sufficiently extended to command the erection of special buildings. Those for Michigan Agricultural College and Cornell University have been designed exclusively for botany; those of the University of Pennsylvania, Iowa Agricultural College and Wabash College are for both botany and zoology; the other institutions named still await the erection of special botanical or biological structures. Harvard University, to be sure, has permanent rooms at the Botanic Gardens, but on account of the distance from the Campus and their limited size, they do not much lessen the need of another special building. In all the twelve institutions, except the University of Pennsylvania and the cryptogamic department of Harvard University, the laboratories described are for the exclusive use of the botanical department, and in all but Michigan Agricultural College the lectures are given in a separate room devoted to that purpose alone.

The number of compound microscopes employed is above twenty on the average for each institution; while the number of students who make use of the laboratories during the year ranges from fifty to one hundred. One can rarely visit any of the laboratories named without finding some original investigation of more or less value in progress, and although the sum total of

such work is not yet large, it is annually increasing and improving in quality.

Our laboratories are now principally devoted to the study of the structure and development of plants; observations are also carried on to some extend upon the habits of plants; but the deeper problems of vegetable physiology are for the most part unprovided for. A point to be borne in mind, at least by those in charge of our principal institutions, is that in the near future there will be a strong demand for adequate laboratory facilities in plant physiology, pathology and bacteriology. These are three great subjects of high scientific and economic importance, and for their best treatment require rooms and apparatus of special design.

If the candid reader has fully read this article, he must acknowledge that there are laboratories in the United States of fair capacity and equipment. Their recent and quiet growth sufficiently explains the general ignorance in regard to them; even among botanists it is for the most part only the younger ones who have felt their direct influence. But such institutions are destined to multiply, and it is confidently expected that at no very distant day botany will be taught by the laboratory method in all our colleges and in many high schools and academies.

1810.—Asa Gray.—1885.

(WITH PLATE XI.)

The eighteenth day of November, 1810, saw the birth of him who was to be the greatest American botanist, and the eighteenth of November, 1885, the seventy-fifth anniversary of that day, brought to him a fitting recognition of his place in the hearts of his fellow-workers.

At a late day it occurred to the editors of the GAZETTE that it would be highly appropriate for botanists to unite in some tribute of love and respect which should commemorate the seventy-fifth anniversary of the birth of ASA GRAY, and should manifest to him somewhat of the admiration and honor in which he is held. Accordingly a letter was sent to all botanists whose addresses could be obtained in the very limited time at our disposal.[1] The responses were prompt and generous. On the 31st of October Messrs. Bigelow, Kennard & Co., of Boston, were

[1] Doubtless many were omitted who would have been glad to join with us. All such omissions must be credited to the absolute necessity for haste.

asked to prepare a design for a silver vase, with appropriate floral decorations. Having designated the shape of the vase and furnished them with specimens and plates of the species to be used in its decoration, this firm submitted a design on November 3d. After consultation with as many friends as possible at Cambridge, the design was accepted, with slight modifications. Work was immediately commenced on it, and the vase was completed on the night of the seventeenth and presented without formality on the morning of the eighteenth of November.

The illustrations which we present give a good idea of the appearance of the vase. It is about eleven inches high, exclusive of the ebony pedestal, which is surrounded by a hoop of hammered silver, bearing the inscription:

1810 November eighteenth, 1885

Asa Gray

in token of the universal esteem

of American Botanists.

The lower part of the vase is fluted and the upper part covered with flowers. The place of honor on one side is held by *Grayia polygaloides*, and on the other by *Shortia galacifolia*. On the Grayia side the prominent plants are *Aquilegia Canadensis*, *Centaurea Americana*, *Jeffersonia diphylla*, *Rudbeckia speciosa*, and *Mitchella repens*. On the Shortia side there are *Lilium Grayi*, *Aster Bigelovii*, *Solidago serotina* and *Epigæa repens*. The lower part of the handles runs into a cluster of *Dionæa* leaves, which clasps the body of the vase, and their upper parts are covered with *Notholæna Grayi*. *Adlumia cirrhosa* trails over the whole background, and its leaves and flowers crop out here and there. The entire surface is "oxidized," which gives greater relief to the decorations. The vase was designed by L. E. Jenks, and the chasing was done by Wm. J. Austin, both with Bigelow, Kennard & Co. The heartiest praise has been bestowed upon the design and the workmanship by all who have seen it.

By the request of the committee greetings in the form of cards and letters had been sent by those who gave the vase. These were placed on a simple but elegant silver plate and accompanied the gift. The inscription on the plate reads:

BEARING THE GREETINGS OF
ONE HUNDRED AND EIGHTY BOTANISTS
OF NORTH AMERICA, TO
ASA GRAY,
ON HIS SEVENTY-FIFTH BIRTHDAY,
NOVEMBER 18TH, 1885.

The expressions of affection and respect which are contained in letters to the committee as well as those which were presented to the good Doctor, together with the united and hearty response to the committee's suggestion, all testify how universal is the esteem and how deep is the affection for this genial man, whom we have thus delighted to honor.

The following response is sent by Dr. Gray:

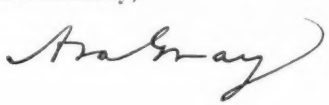
HERBARIUM OF HARVARD UNIVERSITY,
CAMBRIDGE, MASS., November 19, 1885.

To J. C. ARTHUR,
C. R. BARNES,
J. M. COULTER, *Committee*,
And to the numerous Botanical Brotherhood represented by them:

As I am quite unable to convey to you in words any adequate idea of the gratification I received on the morning of the 18th inst., from the wealth of congratulations and expressions of esteem and affection, which welcomed my seventy-fifth birthday, I can do no more than to render to each and all my heartiest thanks. Among fellow-botanists, more pleasantly connected than in any other pursuit by mutual giving and receiving, some recognition of a rather uncommon anniversary might naturally be expected. But this full flow of benediction, from the whole length and breadth of the land, whose flora is a common study and a common delight, was as unexpected as it is touching and memorable. Equally so is the exquisite vase which accompanied the messages of congratulation and is to commemorate them, and upon which not a few of the flowers associated with my name or with my special studies are so deftly wrought by art, that of them one may almost say, "The art itself is nature."

The gift is gratefully received, and it will preserve the memory to those who come after us of a day made by you, dear brethren and sisters, a very happy one to

Yours affectionately,



Laboratory Appliances.

BY JOHN M. COULTER.

The matter presented in this paper is chiefly an editing of information received from some of our principal botanical laboratories, either by correspondence or by personal inspection. As is well known, most of our laboratories are equipped not so much for the use of trained investigators, but to train investigators; hence the teaching aspect is the most prominent, and the most useful notes to our laboratory workers are those which concern methods of teaching. Our teachers are abundantly able to take care of their own original investigations, but in teaching others how to work they are always more than ready to receive hints. This and the other papers of this number, therefore, are not intended to apply to the professional laboratory, but to the teaching laboratory. The writer then intends to act as a middleman for his fellow teachers and interchange for them their ideas upon the subject of appliances.

An almost unanimous expression is that all appliances should be of the simplest kind, as the best of our work has been done by simple appliances, and such are also much cheaper. The attractive catalogues of our instrument makers should be read with care, for they contain many things of very little use in our work and many other things that can be devised at home and answer the purpose just as well. But the notion of simplicity and cheapness must not be carried too far, as, for instance, it is worse than useless to put in the hands of even beginners cheap and hence poor lenses. To classify the subject, we will treat it under the heads suggested by Prof. Bessey.

MICROSCOPES.—*Compound.* Simple low stands seem to be almost universally used, but it is absolutely necessary that they be able to carry any objective. This advice would seem unnecessary, but the writer has in mind more than one laboratory loaded down with stands so cheap that they are really useless for fine work. Foreign stands and those manufactured in our own country are in about equal demand, and it would be hard to convince the users of either that they could better themselves by using the other, all of which shows that good work can be done with both, and a great deal depends upon what one is accustomed to. In some laboratories the stands are so low ("continental" pattern) that the stage may be kept horizontal for all work, which has its advantages. In all cases the microscope is provided with two ob-

jectives, in some cases with one eye-piece, but mostly with two. In the matter of objectives there is a range from 1 inch to $\frac{1}{6}$, the two most commonly used being 1 inch and $\frac{1}{4}$. Such pairs as $\frac{1}{2}$ and $\frac{1}{6}$, $\frac{2}{3}$ and $\frac{1}{3}$ are also in common use. The high power should be of as long working distance as possible. Of course all the laboratories have higher powers that can be used as occasion demands. Several have well emphasized the great advantage of providing thoroughly good objectives even for elementary work, for nothing can be more discouraging or confusing to a beginner than to be asked to try to see with an objective so poor that even his instructor could not use it. Professor Spalding urges the use of a double nose-piece as a great means of saving time as well as wear and tear. In some laboratories eye-piece micrometers are used, and in the University of Nebraska these are simple discs of thin glass upon which a small scale is ruled, and the disc fastened into the tube of the B eye-piece. Such micrometers, when ordered with the instrument, cost about $1.50 each. More laboratories appear to provide stage micrometers, and in some cases one micrometer is made to serve the needs of all the students by each one making measuring slips of his own. This is very simply done by tracing on slips of card-board the micrometer lines by means of the camera with every power used. In this way every camera drawing can be measured directly. In the matter of camera drawing the practice varies considerably. Some require it always; others, in addition to its constant use, require larger free-hand drawings as better illustrating the minor details; others require its use only when exact outlines are needed, or when measurements are to be made; others teach its use and then leave it optional with the student, one saying that "the best workers soon come to prefer the camera;" still others never use it, but only require free-hand drawing. In this wide range of habit the teacher is left to consult his own judgment, except that it would at least seem wise for a pupil to know how to use a camera.

Simple. There is the greatest variation in the matter of simple or dissecting microscopes. The idea in all is the same, but its presentation varies from quite elaborate dissecting instruments, costing $10 or $12 each, to home-made affairs, which seem to answer every purpose, costing 25 cents to $1 each. In the home-made instruments the price depends upon the lens used. At the Michigan Agricultural College Coddington lenses are used of about $\frac{1}{2}$ inch focal distance. The wire handle is held by a narrow slit in a small post in block of wood about 3 inches long. Such an arrangement will make a good dissecting lens cost about $2.10.

This lens can be removed and used as a pocket lens. Probably the simplest form of dissecting instrument is that described by Professor Barnes in this number. In quite common use are the boxed instruments, in which the box is used as the base of the instrument. The Bausch and Lomb dissecting microscopes are in common use, and they are spoken of here in order to recommend those who contemplate getting them, to order the unjointed, instead of the folding stand, as the latter is always a nuisance to pick up by the stage, and, as Professor Trelease writes, "who doesn't pick them up by the stage?"

ACCESSORY INSTRUMENTS.—*Microtomes.* The most universally used microtomes appear to be razors and scalpels, the relative merits of which will probably never be settled. One who uses a razor can not be induced to use a scalpel, and probably the reverse is also true. But either will do if sharp enough, and upon this point of sharpness there is no dissenting voice. A day or two spent in learning how to sharpen a razor or scalpel is never lost time. Plenty of good oil stones should be kept on the tables, and Professor Bessey suggests the use of a mixture of about equal parts of glycerine and water instead of oil. Regular microtomes seem to be not very commonly used, though most laboratories possess one or more for use when necessary, but all the ordinary sections of the laboratory are made "free-hand." As an imbedding substance the laboratories are about equally divided between the pith of elder and that of the common sunflower. Dr. Rothrock says there is nothing better than the latter, but that it should be cut when the stalk is mature and *slowly* dried. In reference to section-cutting the reader is referred to Professor Burrill's paper on the subject in this number.

Forceps. The ordinary forceps supplied with microscopes are universally condemned as coarse and awkward and inexcusable. "Dental forceps," made of steel or brass, nickel-plated, are generally recommended, and if but one is supplied to each student it had better be curved at the tip. They can be bought by the quantity at from 15 to 40 cents each, depending on whether they are brass or steel.

Dissecting needles and *brushes.* All dissecting needles seem to be home-made. The most explicit direction comes from the Michigan Agricultural College, where number 5 needles are broken about $\frac{2}{3}$ from the head and pushed with forceps, blunt end first, into the pith of a small branch of European larch. Of course any fine needle held firmly in any convenient handle is all

that is required. While this does very well for dissecting, some of us are not willing to remove delicate sections with them, and every student should learn from the first to handle all his sections with the greatest care so that it may become second nature. For this purpose the most convenient plan is to fasten a small camel's hair brush to the other end of a dissecting needle. The brush should be one easily drawn to a point. The advantage of having it fastened to a dissecting needle is that when not in use the needle may be kept stuck in the table and the brush thus out of the chance of dust. In this way the most delicate sections can be handled without injury and nice habits of manipulation cultivated.

TABLE ACCESSORIES.—*Reagents, etc.* Here, too, the matter of expense varies widely, some laboratories possessing the elaborate bottles with etched lables and dropping tube attachment that are very complete and very costly. In most cases too many reagent bottles are needed to furnish them all of such grade. Probably the most convenient and economical method is that of those who use ordinary cheap 2 oz. bottles with cork stopper, each stopper having a glass rod or small tube running through it to near the bottom of the bottle. Several object to this arrangement, and prefer to use bottles with ground glass stoppers and small pipettes, such as can be purchased at the drug stores as "eye-droppers," which do not cost more than 5 cents each. The ordinary reagents upon the table are Iodine, Alcohol, Potassic Hydrate, Glycerine, and Water; other reagents, such as acids and staining fluids, not being distributed individually, but supplied as needed. The greatest puzzle seems to be how to treat potassic hydrate so that the bottle may be kept closed and the stopper neither eaten nor stuck fast. Professor Bessey suggests a very simple plan. It is to take a narrow-necked bottle and use for the stopper a pipette with bulb large enough to prevent slipping into the bottle. The bulb will thus drop into the neck and act as a stopper and the pipette be ready for use. Several are troubled with the scum that collects on the potassic hydrate. The best remedy for this is to supply but small amounts of the reagent and when the scum becomes troublesome empty the bottle.

Glass-slips and *cover-glasses* go with the saying and need no word of comment or explanation.

SHELF ACCESSORIES.—*Bell-jars.* For covering specimens and cultures these are indispensable. In many cases tumblers will answer every purpose, but there should be larger bell-jars, and some with ground bottoms.

Glass plates. A number of these should be provided large enough for the bell-jars or tumblers. By this means air-tight cells can be made by oiling the bottom of the bell-jars.

Soup plates are very useful for keeping many specimens in, especially the aquatics in such common use. The glass plates or bell-jars can be used for covering them.

Watch glasses. The ordinary watch glasses are in common use for holding small specimens, and especially for containing the reagents used in treating sections. The ease with which they are overturned is spoken of, and a remedy suggested in securing those with flat bottoms. A still simpler and safer way is to use individual salt-cellars.

Test tubes and *tumblers* are also supplied in all the laboratories.

MOUNTING.—All ordinary mounts are made in water, or in the reagent used. Mounts to be preserved for several days are made in glycerine. Thus far all accounts agree, but when it comes to the question of permanent mounting, there is a great variation in custom.

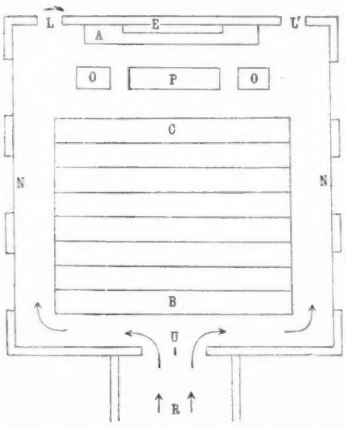
In some cases permanent mounting would seem to be the object of the course, in others it is not employed at all, or even taught. A wise mean seems to be that which teaches how to make permanent mounts, and thus preserves everything worth preserving, but never mounts for mounting's sake. It is questionable whether in the time devoted to the study in most of our laboratories much attention should be paid to this purely mechanical phase of the work. In reference to permanent mounts Dr. Rothrock makes the following suggestion: "When an object is mounted and designed for preservation, an occasional difficulty is experienced as to some suitable substance which is fairly strong and which will not run under the cover when used as a ring to hold the cover in place. For this probably nothing is better than a rather thick solution of gum shellac in alcohol. This will meet the requirement in most cases, providing the object is so thin as to leave no appreciable space between the glass slip and its cover. When the shellac hardens, as it will quickly, a final ring may then be run over it. This is especially valuable when the object is mounted in any of the balsam preparations."

The facts above given embody most of the information received from our best laboratories, and while professional workers may receive from them but few hints, the many who are desiring to equip laboratories in a way both cheap and efficient, will be helped to what they need, by those who have had much experience in such matters.

The Laboratory at Strassburg.

[We are permitted to make the following extracts from a private letter of Dr. Howard Ayres, regarding DeBary's laboratory.—EDS.]

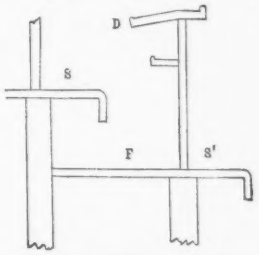
* * * Last July I was in Strassburg to hear DeBary and Oscar Schmidt. The former I heard in his "Allgemeine Botanik Montag bis Freitag, 9–10 v. M., Botanisches Institut." * * * Perhaps a description of DeBary's manner, methods of his laboratory (so far as I saw it) and other details connected with the teaching of botany in Strassburg, may not be uninteresting to you. The new Botanical Institute is a four-story white stone building, situated on the new grounds set apart for the university building, botanical gardens, astronomical observatory, physiological institute, etc., outside the older portion of the city, but within the new fortifications, which are immense earthen embankments. There is a basement for various uses, a ground floor for various others, among which you notice lecture rooms, a second story for general and private laboratories, special library, professors' and assistants' offices or rooms, as you wish to call them.



Plan of Lecture Room: R, main entrance; U, double doors; B-C, seats for 500; N N, large side windows; O,O, desks with drawers; P, Professor's desk; A, table; E, calcium light apparatus; L, L, entrance to Professor's dwelling.

It is 9 A. M. Wednesday morning, as I find myself passing through the large hall towards the double-door, above which is to be seen a porcelain slab bearing the inscription "Hörsaal." On entering there is a passage to right and left behind the last row of seats which are arranged in tiers. On the opposite side of the room is the lecturer's desk, tables, blackboards, calcium light apparatus, etc., and, on each side of his desk, doors which lead into his private rooms—his dwelling—for the professor lives in his "Institute," after the new mode. A diagram of the room may serve a purpose. The seats are plain, straight-backed pine benches, each extending entirely across the room.

To start again: You enter the room, hang up your hat on one of the conveniently placed hooks, take a seat, arrange your "Pandekten" if you take notes, and punctually at 9.15 door L opens and in comes Herr Prof. Dr. DeBary. He bows, "hems" and begins his lecture on Marsiliaceæ. The wall on each side of the blackboard is hung with excellent colored plates, which a normal eye can make use of across the great room! On the table D are seen various glasses of water, pots of plants etc. The professor picks up a green mass and proceeds to divide it into small portions, speaking rapidly the while; each portion finds a separate plate as a resting place; this done, the lecturer opens one of the numerous drawers in O, and takes out lecture (herbarium) specimens, mounted on card and some protected behind a sheet of glass to which the card is pasted. An assistant hands plates and cards to the first and second row of students, and from here on the specimens serve a significant purpose not hard to divine.



Section of Seats: S, S, seats; F, floor; D, desk.

Most of the students bring into class some text-book such as Sachs or Prantl, read and consult figures as the professor talks and sketches or explains his wall cards. Finishing Marsilia, Isoëtes is next taken up, and before the three-quarters of an hour is up he has begun on the Mosses. As a rule the lecture is begun by a short (five minutes) recapitulation of the previous lecture, a most excellent practice for the student. The lecture over, another bow, and the professor disappears through door L. The students are out into the hall without loss of time, some going to another lecture, others up to the general laboratory on the floor above.

On entering the laboratory you find Dr. DeBary there, surrounded by three or four assistants, giving directions for this and that. The professor has a working room—that is, his private laboratory—on this floor. The laboratory rooms are all well lighted, supplied with apparatus of the kind needed by students, and are conveniently near a store-room, containing cases of drawers and shelves with glassware, herbarium and fresh material, reagents and laboratory supplies. In short they are ideal work and study rooms of the present day of botanical science. They were made for that purpose and no other, and since expense was no item in their preparation, and since they were made after the plans of

those who knew what they wanted, the rooms could not but be perfectly fitted up. I think, without doubt, that Strassburg has the best botanical institute in Europe. At present Heidelburg is very well provided, but can not compare with Strassburg.

During the first semester, that is, the winter semester, DeBary usually lectures to his classes in the smaller lecture room, in the second story, near the main entrance to the building. The smaller lecture room is used by the associate professors for their lecture work. In the summer semester, when the classes are too large to get into the small room, the large lecture room is used. DeBary gives courses of lectures on some topic of general interest (e. g. Bacteria) very frequently, and in such cases the lectures are public and largely attended by medical men and those of scientific proclivities. These are, of course, given in the large hall, which never fails to be crowded, hearers finding seats on the steps in the aisles. In all his lectures DeBary uses charts to illustrate, as well as blackboard.

A very common course for students to pursue in their botanical work is to take lectures of DeBary and repetitorium of the Privat Docenten, thus impressing the more important points more clearly on their minds.

The courses offered in Botany for the winter semester of '83–'84 were: *DeBary*, (1) Anatomy and physiology of the vegetative organs of plants; (2) Thallophytes (Algæ and Fungi); (3) Botanical colloquium; (4) Laboratory courses, to be arranged upon consultation. Prof. extraordinarius *E. Zacharias*, (1) Physiology of reproduction; (2) Geographical distribution of plants. Privat Docent *Wortmann*, Physiology of assimilation in plants.

In winter semester of '84–'85, *DeBary*, (1) Anatomy and physiology of plants; (2) Bacteria; (3) Botanical colloquium; (4) Work in laboratory. *Zacharias*, (1) Thallophytes; (2) Useful and commercial plants. *Wortmann*, Repetitorium of the whole of Botany for pharmacy and medical students.

Prof. DeBary is the Dean of the Faculty of Mathematics and Natural Sciences of Strassburg University and Curator of the Botanical Institute and Gardens. His department is, perhaps, the strongest in sciences in the University.

Laboratory Courses of Instruction.

BY JOHN M. COULTER.

In speaking of courses of instruction in botany and the methods used, no reference is made to the old "book methods" of teaching the subject, but simply to what are known as laboratory methods. With this restriction three distinct methods are observable in our laboratories. The first will be understood when it is called "systematic botany"; the second is at the other extreme and ignores systematic botany, being a study of structures and the phenomena of life; the third tries to combine the best elements of both. In some laboratories "cryptogams" are unknown, while in others phanerogams are hardly thought to be worth studying. The second method is a natural reaction from the first, while the third represents the counterswing of the pendulum, the most modern phase, and as we expect, the botany of the future. The fact of it is, botany has grown to be so large a subject, that one teacher with the most liberal allotment of time can not compass it all, even in an elementary way, and he rightly presents that phase of it in which he himself is most interested, as, of course, that seems to him the most important. The only laboratories in this country that can pretend to compass the subject are those at Cambridge, where several instructors are provided. Probably the most satisfactory presentation of the subject will be to select representative courses of instruction from several that have been sent, as expressing the ideas of as many experienced teachers of botany. These courses are taken from those laboratories where but one teacher is provided, and where the time varies from one term to three or four years. In most cases the study is a compulsory one for a short time, but all advanced and really good work is done by students who "elect" the study and pursue it for some time.

In reference to those who have but a term or two to devote to the study, three methods are pursued. One is to use a textbook or lectures and then direct all laboratory work towards the so-called "analysis" of plants, which means, of course, the comparison and naming of phanerogams. This may be called the oldest method and is vastly better than nothing. Another plan is to have the laboratory work all directed towards the examination of facts called for in lectures, such as leaves, branches, roots, etc. This method is practiced in two ways, either as corroborat-

ing statements already given in lectures, or preliminary to such statements. The latter is much the better way, and has been well elaborated by Prof. Beal in his paper on "The New Botany." A third method is to have the class examine a few types of structure from the lowest to the highest, and thus get some general notion of the structure of the vegetable kingdom, as well as the broad outlines of its groups. The last would commend itself as a very philosophical way of treating the subject, if the object is to study botany, and not one department of it.

For work extending through a greater time, such as is obtained in well equipped botanical laboratories, the following courses, already in use in different institutions, are presented. No names are used, as the courses are only selected as types, of which there are many modifications, but they represent very well our present methods of instruction.

1. Beginners use the facilities of a well-equipped laboratory to enable them to master the subject of assigned "lessons" in some text-book like Bessey's Botany. Each man is told to feel free to take up any part of the topic, although advice is given as to what may be preferable. But in every case *the student* decides what he wants to do while he is in the laboratory. Material is provided for all parts of the general topic of study. The student is counseled to familiarize himself with as many types as possible, but he is encouraged to go deeper into a matter here and there, as interest or opportunity may lead him.

Advanced students are advised to take up particular subjects, and to work them out with thoroughness. Here the rule is to select one topic only, or at most a small group of topics, and to get the desired training by great accuracy and attention to all details. The results in such cases are brought together finally in a paper illustrated by the drawings made during investigation.

2. Beginners are started by having them examine a flower, a seed, a plantlet, a naked branch, anything, in fact, that is convenient or in season. Reports of the discoveries made are given before the class and discussed, the teacher directing all these results toward definite and correct conclusions. No order of text is followed, but simply the order of convenience. The literature of the subjects examined is constantly consulted, though generally after the examination has been made. Soon some topic is assigned, which the student must "work up" by observation and present in a final paper.

For advanced students the work is of a similar nature, but closer observation is demanded and a stricter attention to details, and the study of comparison of structures is strongly urged.

3. Beginners are put to work substantially upon the plan introduced by Huxley and Martin in their "Elements of Biology." Of course different plants are used from year to year. One teacher mentions that a great favorite for beginning the study of vascular plants is *Equisetum hyemale*. Throughout the course the student makes all of his own preparations except a few that require special delicacy of manipulation. Accurate drawings and carefully written descriptions are required and are handed in from time to time for criticism and suggestions. In this way the work is done until the student has acquired a critical knowledge of types selected from all the leading groups of the vegetable kingdom.

Advanced students are then called upon to select some group or groups for special study, usually some group of flowerless plants, as needing more aid from the teacher. In the course from which these facts are taken fungi are usually studied, the student making a thorough study of a few representative species, then identifying fifty or more (generally the parasitic fungi), and finally becoming as fully acquainted as possible with the modern literature of the subject. The whole object, and it is an admirable one, is to see that each student learns how to conduct an investigation and use a library. Then follows, if time permits, special investigations and published work.

4. Quite an elaborate course is as follows: The work for the first year consists of systematic work three hours a week and recitation in Gray's Botanical Text-Book, Vol. I. Next is taken up Goodale's Physiological Botany, with histological and physiological work. Along with this a course of lectures on general classification is given, and Bessey's Botany furnishes collateral reading. This occupies the second year. Then, if the student proposes to enter the medical profession, he is directed to a study, analytical and microscopical, of our native medicinal plants. If, on the other hand, he has an aptitude in that direction, and is simply pursuing botany from a biological standpoint, he goes into a study of life histories of the lower plants.

5. Beginners receive a course of lectures on general botany, accompanied by laboratory work on structures illustrative of the lectures and anticipating them. In this way the broad facts of phænogamic structures and life are brought out. This is followed by work in systematic botany, chiefly with the view of teaching methods of "analysis," the reasons for groupings of so many different grades, and the recognition of great groups at sight.

A second year is then spent in the exhaustive study of plant types, one or a few being selected from each group, and all through

the course careful drawings and descriptions are demanded, and frequent lectures attempt to weave together all the facts so as to present the development of the vegetable kingdom and its adaption to habits and surroundings. A library in the laboratories contains all standard books of reference, and a knowledge of the literature of the subjects studied is never lost sight of. At the close of this course papers are prepared upon various subjects that must be presented in a comparative or developmental way, such as "sexual reproduction," "asexual reproduction," "alternation of generations," "development of vegetative structures," etc. During a third year special students select any subject they may feel an interest in or have an opportunity to investigate, the teacher simply seeing that it is not too ambitious or useless.

In the above courses much detail has been necessarily omitted. Other courses differ from them chiefly in the order of presenting subjects. Where and how to begin the study are things not well settled, but in the long run about the same things are taught.

It will be noticed that in the above courses physiology plays but little part, a fact chiefly explained by lack of appliances and lack of time. We venture to predict that if at the end of the next decade the GAZETTE undertakes to give an account of our botanical laboratories, that not only will physiology be found to be well cared for, but other departments not even mentioned in this paper will be prominent.

We can not too strongly emphasize the importance of having the botanical library in the laboratory, that the student may at least become acquainted with the names of writers and their books, and best of all with the literature of the subjects they are investigating.

Several teachers desire to learn subjects which have been of use in the work of special students. For this purpose the following have been presented and their number could be indefinitely increased.

"Structure and development of Onoclea Struthiopteris"; "Influence of climate on vegetation"; "Water in plants"; "Development of stomata of monocotyledons"; "Distribution of the vascular bundles of ferns"; "Biology of the vegetable cell"; "Pathological changes induced by parasitic fungi"; "Development of the pollen-tube in monocotyledons, with the nature and descent of the nuclei"; "The Perisporiaceæ of the region"; "Conjugation of Spirogyra"; "The fibro-vascular system (as a skeleton) of some dicotyledon"; "Water and salts in the various tissues of some plants"; "Plant crystals"; "Development of any

embryo"; "The anatomical study of any plant (not at any one phase, but its anatomical development)"; etc. In addition to these attention should be called to the subjects suggested by Prof. Beal in his "New Botany" already referred to.

If any different ideas in the way of laboratory courses of study, or subjects for special work, can be called out by this article, the GAZETTE will be glad to give them room.

Section Cutting.

BY T. J. BURRILL.

Botanists as a whole seem to be far behind the zoologists in the matter of microscopical technic, especially in the preparation of material. Witness the literature upon injecting, staining, hardening, imbedding, infiltrating, fixing, cutting, handling, clearing—nearly all of it directly for or copied from the animal histologist.

No doubt this comes about naturally enough. In the first place animal tissues require a greater diversity of treatment, and to reach the highest results he who works especially upon them must have resources at command little dreamed of by those whose attention has been exclusively occupied with vegetable preparations. Then those who have earnestly worked upon the minute structure of plants are outnumbered many times by the skillful and intensely devoted animal histologist. The very fact that man's body is animal rather than plant, stimulates investigation on the former instead of the latter side.

But however it may be accounted for, botanists and vegetable physiologists, with only exceptions here and there, are much disposed to remain content with the early methods and processes which zoologists (perhaps zootomists is the word) now consider primitive and superseded. For myself I can not help feeling that I shall gain much by following, where I can not make better headway for my special purposes by special methods, the lead of my brothers, the animal histologists. Fixing my thought now upon simple work for the student botanical laboratory, I restrict myself to my theme. Nothing new is offered. What follows is simply some account of results from personal experience as student and instructor.

The first requisite for good section cutting is an *edge*. In a very large number of instances sections for microscopical study

can not be made too thin. Nothing but the keenest and smoothest edge will make the thinnest shavings. Among common and usually available articles a good razor furnishes the best edge. The form of the blade is also best, that is, some razors more nearly meet the requirements, so far as form of blade is concerned, than any other common knife. The requisites in a razor for this purpose may be put down as follows: (1) The material must be the best steel, suitably tempered; (2) the edge should be straight from toe to heel and free from "wind" and wabbles; (3) the blade should be of good width, the back firm and heavy and so shaped that in the process of honing the edge will remain straight; (4) both surfaces should be moderately hollow ground, the upper one by preference the most, but neither so much as to make the edge portion sensibly flexible; (5) the upper surface at least should be perfectly polished and free from engraving of any kind. Such razors, or nearly such, can be found in the usual markets and at reasonable cost; the highest priced ones are not commonly the best for our use.

For sharpening the best razor hone should be used. This latter must be perfectly level and free from gritty granules, and the blade must be held scrupulously flat. The best edge is secured by turning the razor at every stroke, after the usual manner, provided each stroke is accurate enough to always rest edge and back upon the stone. After honing until a perfectly true and keen edge is secured, finish upon a leather strop. The latter must be frequently used, but the usual artificial hones should be avoided.

Generally the operator will have to keep his own razor in order, and he can not be too careful about it. It will not do to trust the skill of the common barber in sharpening. Better study his own needs and then acquire the ability to meet them. An examination of the edge (held toward the light) with a magnifier will be instructive. The sharpened razor should never be used for anything besides cutting the thin sections. All preliminary whittling is to be done with another knife.

Having a proper *edge*, the next thing to be here considered is the manner of holding the object to be cut. For some purposes this can be sufficiently well done in the fingers, either by itself or between such substances as pith, cork, etc.; but in the better work contemplated in this description some form of a microtome is essential. Some persons become very expert by the free hand method, and all will do well to practice it at times, but all ought also to know that anyone, however expert, can make vastly better sections, at least for some and usually for most purposes, by the

use of a proper holding instrument. Undoubtedly the sliding microtome is the best form, and an object holder that grasps the material is better than one in which the latter is wedged or imbedded; but these are also much more expensive in construction than the ordinary "well" microtome with a screw for raising the object. For this reason my own laboratory is supplied with the latter form of instrument, each student having one clamped to his table. For special work resort is had to the better instruments.

There are, however, two important improvements upon the old well microtomes which can not be dispensed with without serious loss in efficiency. The first is a glass top, the second is a removable tube fitting the well. My instruments are made to order, and cost two and a half dollars each. They are, however, of iron; brass is better. Each is furnished with two or three brass tubes, in which the objects are placed, instead of putting the latter directly in the well itself. The tubes fit the well exactly, and are closed at bottom with a cork. This latter may be pushed up with the object and its holding material to the proper height before placing the tube in the well. The screw works on the tube, raising the whole together. In this way not only is imbedding much easier, but the certainty of the proper movement consequent upon turning the screw is far greater. There is always the same amount of friction to overcome and there is no elastic spring to interfere. The microtome must be fitted for clamping to the edge of the table.

The object to be cut is wedged more or less firmly in the well tube, according to the resistance offered to the knife. Delicate things may be put into pith, and by sloping the latter away so as to leave little of it to cut, the softest leaf or petal can be thus held sufficiently firm, without bruising. The latter is not nearly so likely to happen as when held in the fingers. Harder substances may be held by portions of velvet cork, this also being sloped properly away in a cone shaped top.

In numerous instances, however, some method of imbedding is greatly preferable to simple wedging in the tube holder. For this purpose there are many substances having special merits, and there is no one superior to others for all purposes. The nearest to this, however, for botanical uses is a soap mass, the only one to be herein described.

Take good, white hard soap ("Ivory" soap is excellent), cut in very thin slices, and having gently compressed them in a suitable dish, pour in enough 95 per cent. alcohol to somewhat more than cover the sliced soap. Heat to near the boiling point of the

alcohol until the soap is dissolved. Add now a small quantity of glycerine. The amount of the latter can be readily ascertained by pouring out a few drops of the warm mixture and allowing it to cool. Without any glycerine the mass instantly congeals into a white friable substance quite unfit for our purpose, but as a proportion is gradually added the mass hardens less and less rapidly and becomes more and more transparent. For soft tissues the imbedding mass may be thus made as transparent as glass and exquisite for cutting. For harder substances less glycerine must be used.

With this imbedding material fresh vegetable tissues need no preceding preparation, provided there is not a large amount of water in them, while substances preserved in alcohol are admirably adapted for immediate use. If infiltration is desired it is only necessary to keep the object some time in the warm mass. It is clean, and the instruments remain clean. The transparency enables one to see clearly the position of the object and to manage well the cutting. Thin sections are not so liable to roll up as with most other masses. It is readily soluble in water, but not in cold alcohol. In cutting it is better to keep the razor and the object wetted with the latter and transfer the sections to the former. If a well tube to imbed in is not at hand, pour the melted mass into any convenient dish or paper tray, immerse the object, and when the mass cools, cut it out and shape as required.

In cutting let the razor rest flat on the glass top of the microtome and *and hold it firmly with both hands.* Make a long draw or push stroke, so that a considerable portion of the edge of the razor is used each cut. See to it that there is not the least vibration of the blade by which the edge may be nicked. If everything is in order, and the handling properly done, it is surprising how hard substances may be cut without this last occurrence. We ought not to be satisfied until we can readily cut sections one-thousandth of an inch thick without tearing or bruising.

GENERAL NOTES.

Starch Grains.—Starch grains in the cells of potato can be beautifully shown by first partially drying the part from which sections are to be made, thereby aiding materially the process of cutting. Remove from a fresh tuber a prism one-fourth to one-half an inch in diameter and an inch or more in length. Expose for a few minutes to moderate heat (hot air from a register is excellent) until the *surfaces* are quite free from moisture, then allow to remain in the ordinary air of the laboratory for twenty-four hours. The consistence

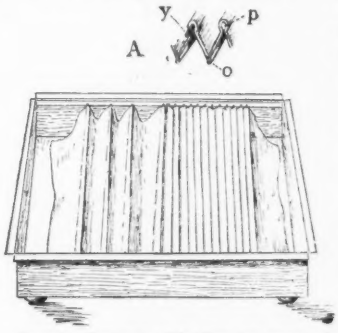
will now be excellent for cutting, and clean cells without ragged remains of ruptured ones may be seen beautifully filled with starch like baskets of fruit. Mount in water. Stain if desired with iodine.—T. J. BURRILL.

A Spring-Clip.—The accompanying illustration shows a form of spring-clip for microscopical purposes which is at once the cheapest, most easily made and most efficient one with which I am acquainted. It is made of a rather large hairpin, the ends being bent into shape by means of ordinary pliers—preferably round pliers.

A spring-clip.

Quite a wide range of pressure may be readily obtained by bending with the fingers the upper arm to or from the lower.—F. L. SARGENT, *Botanic Garden, Cambridge, Mass.*

A Germinating Pan.—Various methods have been used for testing the per cent. and time of seed germination. Those most commonly adopted in this country and also abroad have been to place the seeds on the surface of porous tile, smooth sand or compacted earth. Without stopping to point out the defects and inconveniences of these methods, I desire to describe an apparatus devised at the N. Y. Agricultural Experiment Station, and which has been found so satisfactory as to supersede all other sorts of germinators at that institution, for general use. It consists of a pan 10 by 14 inches wide, and 3½ inches deep, to be covered with a pane of glass. Along the sides is a ledge ⅜ in. wide, and as much below the upper edge. The pan is best made of tinned copper, the ledge formed by the proper shaping of the sides of the pan, and the edges on three sides turned over to form a groove into which the pane of glass may be slid from one end. These details are not shown in the cut. The seeds are held in the folds of cloth. A strip of white Canton flannel is taken sufficiently wide so that when hemmed on both sides (to prevent seeds slipping out of the ends of the folds) it will be the same as the inside width of the pan. A long enough strip is used to have about twenty-four folds 1½ inches deep, and leave a flap of several inches at each end. The upper margin of the folds is sewn across to permit a ⅜ inch brass rod to be run in from which the cloth is suspended in the pan, as shown in the cut. The lower margins of the folds are also sewn across to make them stay in place better. The total length of the strip after the sewing is completed is about a yard. Two such strips are used in each pan.



Germinating pan with glass top removed: *A*, details of folded cloth; *y*, projecting end of rod which runs through the upper seam (*p*) of the folds; *o*, lower seam of the folds.

To put the pan into use, it is filled part full of water, two of the prepared

cloths put in, the glass cover adjusted and the whole boiled over a lamp for a short time. This is necessary in order both to thoroughly wet the cloth and to kill any mold or other germs. When again cool, adjust the cloths on the brass rods, and put in the seeds. Each fold will hold twenty-five large seeds, like beans, and a hundred or more small seeds. Water is placed in the pan, but not enough to touch the folds of cloth; the four flaps drop down into it, however, and keep the cloths sufficiently wet by capillarity, which is increased by the long nap on the under surface of the cloth. The folds are numbered consecutively and the record kept by the numbers.

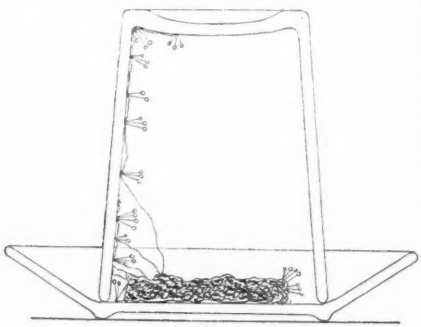
The advantages in a pan of this kind are the facility with which the seeds may be examined and counted, the thorough and uniform moisture of the seeds throughout the longest trials, its lightness and cleanliness. It is necessary to renew the cloths from time to time, as they will slowly rot out, even with the best of care.

This has been recently introduced, I am told, at the U. S. Department of Agriculture, and at one or two other places, under the name of the Geneva germinator.—J. C. A.

A Convenient Laboratory Plant.—One of the plants that has proved most instructive in our laboratory is a *Mucor*, of the Rhizopus section, which springs up spontaneously and can be left growing almost indefinitely on bread.

On freshly cut wheat bread it makes a prompt and rank growth when covered by a tumbler, and illustrates heliotropism very strikingly if grown so as to be strongly shaded on one side and well lighted on the other.

The best cultures for study are usually obtained by inverting tumblers over pieces of rather stale bread, which often fails to show the mold for a number of days (sometimes a week or more). When this appears it usually grows slowly, so that the plants are not crowded. At first the colorless, stolon-like hyphæ spread slowly over the bread, after which they creep off onto the glass, usually reaching a length of a half inch or less, but occasionally becoming two or even three inches long. Where they touch the glass, they attach themselves by short rhizoids and send up tufts of (usually) 2 to 5 pale-brown fruiting hyphæ, each ending in a black sporangium. Where the piece of bread is small, they are scattered over the glass so as to be accessible for observation, without disturbance, several weeks, and at first manifest a slightly developed negative geotropism.



Culture of a Mucor under a tumbler.

Although the bread appears quite dry, it really contains a considerable

quantity of moisture, which, nevertheless, evaporates very slowly. But the mold abstracts much of this and promptly sets it free by transpiration; and when a piece of bread nearly as large as the mouth of the glass is used, the transpired water is so copious that it soon collects on the sides of the glass, appearing first as a faint mistiness, then as drops. Even before the moisture is visible, the plants show a marked sensitiveness to its presence, the tufts of fertile threads standing out at right angles to the damp surface. When the inverted bottom of the tumbler is reached, the same repellent action is evident, the tufts being pendent, while the few which develop in the angle around the bottom bisect it. Now and then a cluster of sporangia comes from the exact edge of the piece of bread, when it makes equal angles with the side and top.

The figure, representing a few of the many cases observed in a single culture, illustrates this negative hydrotropism better than a description. Both heliotropism and hydrotropism are so much stronger than geotropism in this common mold that they are very easily demonstrated to a class by it.

WM. TRELEASE.

Cultivation of Pollen-spores. — In the cultivation of pollen-spores those of monocotyledons are most responsive, and of all that have been tried those of Tradescantia are the most serviceable. The pollen tube begins to develop in a very few minutes, and within an hour becomes many times longer than the spores and has received the spore contents. An ordinary moist chamber is used, constructed of blotting-paper or card-board, as suggested by Bower and Vines in their Practical Botany, p. 16, and by Goodale in his Physiological Botany, p. 430. The points which experience with this special plant suggests are:

1. The culture drop, for a quick response, should be a saturated solution of cane sugar.

2. The spores should be first placed upon the cover glass, and then the culture drop added. If the spores are sown on the culture drop they will remain too far removed from the objective, and the tubes will mostly grow towards the objective and so be seen in optical section instead of in profile.

3. Spores should be obtained from flowers that have been open for some time.

Tradescantia is so common, the moist chambers are so simple, and the response so immediate, that it would seem a pity for any student to fail seeing the extine ruptured and the intine developing into a pollen tube.—J. M. C.

A Cheap Dissecting Microscope.—No laboratory or workers need be unsupplied with dissecting microscopes. If even the cheapest form manufactured by the opticians is beyond the means of the school or individual, an effective stand may be made as follows: Into any block of wood of suitable size fix upright a short piece of stiff wire or rod having a smooth surface. Bore a hole in a fine-grained cork, a little to one side of the center, so that the cork will slide smoothly on the rod. Bend one end of the smaller wire into suitable shape to hold whatever lens is at hand, and make a hole of proper size in the cork at right-angles to the first. This arrangement gives ample and smooth movements of the lens in any direction for adjustment. The plan may be elaborated to any desired extent. If the rod be fixed in a plain piece of board, dissecting may be done on a piece of glass laid flat on the board. Pieces of black or white paper underneath will give the backgrounds against which any object may be seen. For dissecting in liquid a deep individual butter plate answers well. If one desires some transmitted light the object may be dissected on the bottom of an inverted tumbler which has a *smooth* concavity. Sloping blocks may be placed at the sides for hand-rests. Still better illumination may be had by fixing two such blocks, one on each side of the upright rod, and placing between them a strip of mirror glass inclined at an angle of 30°–45°. In fact,

with a little ingenuity and mechanical skill, one may construct a stand for dissecting which will equal in efficiency any of the simple microscopes offered for sale. Of course the lenses must be bought. They may cost any sum the purchaser chooses, from 25c. to $10. The most convenient powers are an *inch* and a *half-inch*, magnifying respectively 10 and 20 diameters. If one already has objectives for compound microscope nothing better can be got.—C. R. B.

A Method of Spore Germination.—In view of the difficulty experienced in growing the spores of those Pteridophytes whose prothallia are destitute of chlorophyll, the following experiments, though incomplete, may perhaps be of service for further investigations:

The spores were sown upon the surface of fine earth, in shallow earthen saucers, and covered with small frames constructed as follows: A shallow box, or rather frame, about four inches across, was made from four narrow strips of wood, the bottom being constructed of fine wire gauze, thus forming a sort of small sieve. This was filled with fine earth pressed firmly down so as to allow as little air as possible to get in between the bottom of the box and the surface upon which the spores were sown. The spores were thus practically under ground and yet could be readily examined by simply lifting the frame. By this process a number of spores of *Botrychium ternatum* were made to germinate, and small prothallia were obtained. In this case germination did not occur until nine months after sowing the spores.

The construction of the frames used was due to a suggestion of my brother, Edward D. Campbell, on my explaining that I wished to contrive some means of easily getting at spores that were to be sown under ground.—Douglas H. Campbell, *Detroit, Mich.*

Fungus Spores.—Fungus spores, as a rule, germinate best when sown *upon* a drop of water in which there is dissolved a small proportion of gum. If the aqueous drop is put on a slide, the spores dusted on the slightly viscid fluid and the whole kept in a moist chamber for twenty-four hours, at the ordinary temperature of the laboratory, an examination will often be rewarded by an instructive exhibition of germinal tubes. The same may be said of pollen grains, though the addition of a little nectar or sugar to the fluid, in this case, is useful.—T. J. Burrill.

Potassic Hydrate Bottle.—In a laboratory where a considerable quantity of potassic hydrate is uesd, a bottle furnished with a siphon (kept always filled, closed by a pinch-cock near the lower end), and a U-tube will be found convenient. The U-tube should be sealed with potassic hydrate so that the air which enters the bottle, as its contents is used, may bubble through this liquid in the tube and thus be deprived of the carbonic dioxide which would otherwise cause a precipitate in the bottle. By such an arrangement one may always have clean potassic hydrate in any quantity without annoyance from the pellicle of potassic carbonate, sure to be formed in open bottles, the sticking of glass stoppers, or the dissolution of cork ones.—C. R. B.

Streaming of Protoplasm —The streaming motion of protoplasm can be exhibited very satisfactorily in the thin membrane (upper epidermis of scale-leaf) found between the scales of the bulb of the common onion. All that is necessary to do is to transfer a piece of the fresh membrane, snipped off by a pair of scissors, to a drop of water on a slide, cover and examine with a power of four hundred or so times. The temperature of a comfortable room is about right, with less heat the movement is very slow. Success is more certain if the bulb has started to grow, as they often do in a cellar.

Care should be taken in removing the membrane, for the cell walls are very delicate and easily wrinkle, forming unsightly and annoying, irregular lines over what should be the clear open cell.

The material commends itself for its accessibility at any time, and espe-

cially in winter when other things may not be readily obtained, and for the extreme ease of preparation.—T. J. BURRILL.

Laboratory Articles in Back Numbers.—This journal has already published considerable, during its ten years of existence, in reference to laboratories. To make this scattered information more readily serviceable, we herewith give references to the more important articles and items:

Teaching and means of illustration.—Methods of teaching, VI, 233, 302: Making of charts, VI, 186.

Instruments and material.—Convenient dissecting microscope, III, 37; Compound microscopes for botanical work, VI, 193; Apparatus for m easuring growth, VI, 172; Stopper for bacteria culture vessels, X, 308; Material for laboratory use, IV, 196, V, 133, VI, 244, 294, VII, 10, 35, 125.

Manipulation.—Section cutting, V, 28, VI, 194; Mounting, V, 27, VI, 194; Staining, IV, 201, V, 65; Cleaning cover-glasses, V, 30.

Physiological demonstrations.—Direct observation of the movement of water in plants, VIII, 260; Study of ovules and germinating pollen grains, X, 353; Growing fern prothallia, X, 356; Cultivation of spores, VI, 204; Cultivation of bacteria, X, 391; Demonstration of continuity of protoplasm, VIII, 323, X, 322.

Herbarium work.—Applying pressure in making botanical specimens, I, 21; Pressing to preserve color, VI, 256; Cement for herbarium, IV, 215, IX, 62; Carbon bisulphide for preserving plants, II, 101.

EDITORIAL NOTES.

THE NEW botanical laboratory at the University of Strassburg cost $130,000.

HOGG'S standard work on the microscope has reached its eleventh edition.

EDMOND BOISSIER, a well known botanist, died September 25, at Valleyres, Switzerland, at 76 years of age.

DR. GRAY WRITES: *Coreopsis delphinifolia* has been lost from the Botanic Garden at Cambridge. Who can generously supply it anew, from roots or seeds?

BACTERIOLOGY receives the chief attention of the new Institute of Hygiene recently founded in connection with Berlin University, and presided over by Dr. Koch.

IT MAY BE interesting to know that the contributors to the Gray vase represent several provinces of British America and thirty-three States and Territories of the Union.

OUR JANUARY NUMBER will contain a portrait and biographical sketch of Dr. Asa Gray, together with a few of the congratulatory addresses and poems sent to him on his last birthday.

THE SHAW SCHOOL OF BOTANY was opened November 6, with a public lecture by Dr. Trelease, to be followed by a course of four lectures on fertilization of flowers. The laboratory work began promptly with fifteen students, who took up the study of grasses.

THE NEW LABORATORY for the investigation of plant diseases in the Agricultural Department at Washington, makes slow progress toward securing an outfit, owing to lack of funds. It is hoped that Congress will make early provision for this need at its present session.

WE HAVE MADE arrangements by which any who desire can obtain excellent cabinet photographs of both sides of the Gray vase, which, of course, far sur-

pass any engraving that can be made. They can be had at 50 cents per pair, or single ones of either side at 25 cents, by addressing PACH'S STUDIO, CAMBRIDGE, MASS.

AN EXCERPT from the transactions of the Kansas Academy of Sciences gives a list of the parasitic fungi of Kansas by Professor Kellerman. It includes 181 numbers and closes with indices of genera and host plants. *Septoria Kellermaniana*, a new species by von Thuemen, on *Vitis cordifolia*, is described; the other new species await description in the Torrey Bulletin.

THE MOST immediate relative of the mahogany tree, *Swietenia humilis*, Zucc., has never been found since it was collected by Karwinski, more than fifty years ago. Considerable interest consequently attaches to fine specimens of flowers, leaves and mature fruit which have recently been sent to the Gray Herbarium by M. Dugés. This species, like its congener, is an inhabitant of tropical Central America.

THE LAST NUMBER of *Drugs and Medicines of N. A.* contains some excellent figures of medicinal plants and quite sustains the promise of preceding numbers. In the figure of *Aquilegia Canadensis*, however, the artist forgot the five styles which ought to be exserted from the stamen cluster. *Aconitum Columbianum* Nutt. should be written instead of *A. Fischeri*, as our American species is distinct from its Asiatic representative. Cf. Bot., Calif., ii. 428.

PROFESSOR TRELEASE'S paper on "Several zoogloeæ and related forms" contains descriptions of new species of chromogenous bacteria as follows: *Bacterium candidum*, *B. aurantiacum*, *B. luteum*, *B. chlorinum* and *B. incarnatum*. The other species studied were *Micrococcus candidus* Cohn, *Bacterium tumescens* Zopf, *B. violaceum* Bergonz., *B. hyalinum* Ktz., *Clathothrix dichotoma* Cohn, *Leptothrix buccalis* Robin, *Saccharomyces glutinus* (Fres.), and var. *candidus* of the same, named by Trelease.

THE MOVEMENTS of protoplasm in plant cells is much interfered with by the usual method of sectioning and mounting in water. Dr. de Vries has had marked success by using a 5 per cent. sugar solution for moistening the knife and mounting. After mounting, the solution is removed from under the coverglass by means of blotting paper and a fresh drop supplied. The preparation is then allowed to stand an hour or two before examination to permit the protoplasm to recover its mobility.

INTERESTING EXPERIMENTS have been tried on the temperature of growing fruits by Dr. Ord, given in the *British Medical Journal*. He used a slender, pointed thermometer which could be easily thrust into the fruit. The trials were made on cucumbers in a hot-house, and the variations due to fluctuation were indicated by the temperature of a bottle of water suspended at the side of the fruit. A difference of one or two degrees was found between the temperature of green fruit and the air or water in the bottle, the latter two usually varying one way or the other by about a degree; a difference of a degree was also recorded between the two extremities of the fruit, which represent different stages of growth. This is suggestive of an interesting line of research.

THE OCCURRENCE of protoplasmic rotation in plant cells has recently been carefully investigated by Dr. H. de Vries. With the exception of *Vallisneria* and *Anacharis* it is usually noticed in cells which are not united into tissue, *e. g.*, filaments of fungi, algæ, *Chara* and *Nitella*, and in higher plants in hairs, pollen tubes and very young embryos. He sought to determine if it did not occur in other cells, and has arrived at the conclusion that (1) it occurs in cells of the most diverse tissues, and that (2) it may be observed in all strongly growing cells in any organ taken from large, vigorously assimilating plants. *Tradescantia rosea* and *Tropæolum majus* were the special examples investigated.

55260